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ELEVATED TEMPERATURE MECHANICAL PROPERTIES OF TWO CAST ALUMINUM ALLOYS

A. W. GUNDERSON

TECHNICAL REPORT AFML-TR-69-100

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AIR FORCE MATERIALS LABORATORY
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FOREWORD

This report was prepared by Allen W. Gunderson of the Materials Engineering Branch, Materials Support Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio. This program was conducted under Project No. 7381 "Materials Applications," Task No. 738106 "Engineering and Design Data." This report covers work conducted from September 1967 to December 1968. The manuscript was released by the author in February 1969 for publication as a technical report.

The testing portion of the program was accomplished by Richard J. Marton and the computer data reduction by Robert Smith of the University of Dayton Research Institute.

The items tested in this program were commercial items that were not developed or manufactured to meet any government specifications, to withstand the tests to which they were subjected, or to operate as applied during this study. Any failure to meet the objectives of this study is no reflection on any of the commercial items discussed herein or on any manufacturer.

This technical report has been reviewed and is approved.

Albert Olevitch

ALBERT OLEVITCH
Chief, Materials Engineering Branch
Materials Support Division
Air Force Materials Laboratory

ABSTRACT

A test program was conducted to obtain mechanical properties data on two aluminum casting alloys. Work included tensile, creep, and rupture tests at room temperature, 300, 400, 500, and 600°F. The alloy Hiduminium RR-350 was developed as a high temperature alloy. Its room temperature properties were moderate but it held its strength quite well up to 600°F. The alloy CH-70 was developed as a high strength, high performance alloy in the 60,000 ultimate tensile strength, 50,000 yield strength, and 5% elongation range. Tensile properties of CH-70 held up well at the 300° test temperature but decreased rapidly at higher temperatures.

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ILLUSTRATIONS

ILLUSTRATIONS

ILLUSTRATIONS (Cont'd)

INTRODUCTION

The emergence of high strength and temperature resistant aluminum casting alloys in recent years has led to their increased usage in aerospace systems. The castable alloys provide a design flexibility and economy not attainable by wrought products and processes.

The two alloys tested in this program are of a new generation of aluminum casting alloys. The major portion of the test program was conducted on Hiduminium RR-350 alloy. Hiduminium RR-350 is a sand-casting alloy specifically developed for high temperature applications and is jointly patented by High Duty Alloy and Rolls-Royce Limited of England. The Hidiminium specimens were furnished the Air Force Materials Laboratory by the General Electric Company Flight Propulsion Division. The material has been used as a scavenge pump housing material on the J-93 engine, and is scheduled for use in controls and accessory systems in the GE-4 engine (SST).

The second alloy evaluated was CH-70, a high performance alloy developed by Aluminum Company of America. The specimens of CH-70 were furnished by Northrup Corporation Norair Division. Norair recently completed a room temperature mechanical property evaluation of several high strength aluminum castings alloys, including CH-70, and the results are to be published as an Air Force Materials Laboratory Technical Report AFML-TR-68-8.

The present effort was conducted to establish the properties of the RR-350 alloy, particularly for extended periods of exposure, and to establish the elevated temperature capabilities of the CH-70 alloy.

EXPERIMENTAL PROGRAM

The Hiduminium RR-350 alloy is used in jet engine components, such as housings and cover boxes for accessory drives. In such locations, the ambient temperatures may exceed 400°F. RR-350 in limited testing previously conducted by High Duty Alloys had shown attractive high temperature strength. This test program, outlined in Table II, was designed to determine the effect of high temperature environments on the RR-350 alloy, particularly over extended periods of time, and to establish a comparison with the elevated temperature properties of the CH-70 alloy.

The CH-70 test program, Table II, followed the same temperature levels as the RR-350, but because of the limited number of specimens available and the availability of mechanical property data from other sources, its evaluation was primarily for comparison only.

SPECIMEN INFORMATION

The RR-350 alloy was from three sources. Separately cast test bars from two vendors were machined to the 2-inch gage section threaded specimen configuration shown in Figures 2 and 3. Also, flat specimens were machined from actual component castings (one is shown in Figure 4).

All of the CH-70 specimens were taken from wing span castings such as shown in Figure 5. Flat specimens with a 1-inch gage length were machined.

The nominal chemical compositions for the two alloys are given in Table I.

The standard heat treatment of the Hiduminium RR-350 alloy was:

5 hours at 1004-1012°F
Quench in boiling water
Age 16 hours @ 414-424°F.

For the portion of the test program investigating the effect of age temperature on tensile properties, the listed temperature was used instead of the standard.

The vendor "B" specimens listed as overaged were aged 16 hours at 500°F in addition to the standard age.

The CH-70 alloy was heat treated to the T-6 conditon by the following procedure:

2 hours at 975°F
4 hours at 985°F
12 hours at 995°F
1 hour at 985°F
Water quench (less than 10 seconds delay)
Age 18 hours at 310°F

The test plan for both alloys is given in Table II.

TEST METHODS

Tensile testing was done on a 50,000-lb Baldwin Weidemann Universal Testing Machine. Autographic load-strain data was recorded as shown in Figure 5. For the room temperature tests the strain was measured by a Baldwin Microformer transducer. The elevated temperature test used an Arcweld extensometer which also utilizes a linear variable differential transformer.

Creep and creep rupture testing were accomplished on Satec-Arcweld test frames with temperature control by either a Leeds and Northrup or an Arcweld controller. Data was recorded automatically by the MAAE Data-Logger unit.

RESULTS

The tensile properties of Hiduminium RR-350 held up fairly well to the 600°F temperature level. As can be seen from the data, the cast test bars are noticeably stronger than specimens machined from component castings. The overage condition of some vendor "B" specimens did not improve the tensile properties. The vendor "A" specimens gave slightly higher tensile values than the vendor "B" specimens. The tensile properties of RR-350 are listed in Tables IV through VII and show graphically in Figures 6 through 8. Test temperatures to 600°F were used to characterize these properties. Tensile properties of CH-70 are given in Tables VII, IX, and X.

The creep rupture and creep tes s for RR-350 are presented as one group of data because of the overlapping values obtained. The creep rupture tests were originally designed to anticipate rupture in 500 hours and the creep tests anticipated deformation in the 0.1 to 0.2% range. The curves shown are for representative specimens from each temperature. The creep and creep rupture specimens were also tested at temperatures up to 600°F. This data is presented in Tables XI through XVII and Figures 9 through 16.

In both the tensile property tests and the creep tests, the component specimens were lower in values than the cast test bar specimens.

The CH-70 alloy was not designed specifically for elevated temperature applications and the values obtained in this program should not affect its major usage as a high strength casting alloy for use at low temperatures. As shown in Figure 17, the tensile properties withstood 300°F fairly well, but then decreased rapidly.

The creep test results for the CH-70 at 400°F show that temperature to be near the upper limit for the material's usefulness (Figure 19).

Comparison data is given in Figures 20 and 21.

CONCLUSIONS

1. Hiduminium RR-350 exhibits fair tensile properties up to 600°F.

2. Hiduminium RR-350 creep strength drops rapidly after 500°F.

3. The CH-70 alloy has good tensile properties up to 300°F. At 400°F, the tensile values are about one-half room temperature values.

4. CH-70 creep specimens show little elongation before fracture.

TABLE I

NOMINAL CHEMICAL COMPOSITIONS FOR RR-350 AND CH-70

ELEMENT	PERCENT HIDUMINIUM RR-350	CH-70
COPPER	5	4.5
NICKEL	1.5	---
SILVER	---	0.7
MANGANESE	0.25	0.30
MAGNESIUM	---	0.27
TITANIUM	0.2	0.29
COBALT	0.25	---
ANTIMONY	0.25	---
ZIRCONIUM	0.25	---
SILICON	---	0.06
IRON	---	0.02
ALUMINUM	Remainder	Remainder

TABLE II

TEST PLAN FOR ALUMINUM CASTINGS

HIDUMINIUM RR-350 CH-70

EFFECT OF AGE TEMP ON TENSILE PROPERTIES		CAST TEST BARS VENDOR B		CAST TEST BARS VENDOR A		COMPONENT CASTINGS		WING SPAR CASTING	
		smooth	$K_t=3$	smooth	$K_t=3$	smooth	$K_t=3$	smooth	$K_t=3$
TEST TEMPERATURE	AGE TEMPERATURE								
ROOM	414-424	3	1	1	1	3	3	3	3
ROOM	500	3	1	1	1				
ROOM	550	3	1	1	1				
ROOM	600	3	1	1	1				
EFFECT OF TEMP ON TENSILE PROPERTIES			smooth over-age						
TEST TEMPERATURE	HOLD TEMPERATURE								
300	1000	3	1	1		3		3	
400	1000	3	1	1		3		3	
500	1000	3				3		3	
600	1000	3	1	1		3		3	
400	1/2	3						3	
400	500	3				3		3	
STRESS RUPTURE TEST TEMPERATURE			notched $K_t=3$						
300		1				1			
400		3	1	1		3		3	
500		1				1			
600		3	1	1		3		3	
CREEP (.1 to .2%) TEST TEMPERATURE			smooth over-age						
300		1				1			
400		3	1	1		3		3	
500		1				1			
600		3	1	1		3		3	

TABLE III

HIDUMINIUM RR-350 CAST TEST BARS,
EFFECT OF AGE TEMPERATURE ON ROOM TEMPERATURE TENSILE PROPERTIES

SPEC. NO.	ULT. KSI	0.2% Y.S. KSI	% ELONG.	AGE °F	AVERAGES ULT.	AVERAGES Y.S.	AVERAGES ELONG.
B25	39.99	32.31	1.5	STD	41.64	32.83	1.3
B39	43.31	33.27	1.15	STD			
B49	41.61	32.92	1.25	STD			
B115	36.69	24.31	1.85	500	37.65	24.11	1.95
B127	38.45	25.59	2.1	500			
B135	37.81	22.44	1.9	500			
B107	37.05	21.83	2.65	600	36.53	22.07	2.33
B119	36.49	21.97	2.05	600			
B131	36.04	22.40	2.3	600			
B111	37.70	21.30	2.8	550	36.83	22.21	2.43
B139	35.12	22.64	1.95	550			
B143	37.67	22.70	2.55	550			
A132	42.89	34.03	1.35	STD			
A8	38.19	27.00	1.85	500			
A52	38.57	24.20	2.35	600			
A23	38.55	25.42	2.3	550			
B80	39.34	Notched		STD			
B95	39.95	Notched		STD			
B103	34.13	Notched		500			
B123	33.06	Notched		600			
B147	32.27	Notched		550			
A57	40.83	Notched		STD			
A3	36.24	Notched		500			
A43	34.08	Notched		600			
A15	33.92	Notched		550			

TABLE IV

HIDUMINIUM RR-350 VENDOR B CAST TEST BAR SPECIMENS,
EFFECT OF TEMPERATURE EXPOSURE ON TENSILE PROPERTIES

						AVERAGES		
SPEC	ULT.	Y.S.	ELONG.	TEMP	TIME	ULT.	Y.S.	ELONG.
B31	39.50	29.71	2.05	300	1000	39.68	30.45	1.9
B37	39.55	31.11	1.95	300	1000			
B55	39.99	30.52	1.70	300	1000			
B88	33.97	23.37	2.65	400	1/2	33.64	25.06	2.63
B92	33.63	26.53	2.55	400	1/2			
B96	33.31	25.27	2.7	400	1/2			
B21	34.72	24.24	2.6	400	500	33.69	23.95	2.33
B57	33.22	23.73	2.5	400	500			
B77	33.14	23.77	1.9	400	500			
B23	33.61	25.77	2.45	400	1000	34.12	25.02	2.53
B43	33.63	22.86	2.40	400	1000			
B83	35.11	26.44	2.7	400	1000			
B18	30.465	22.75	3.45	500	1000	30.09	22.5	3.53
B62	30.465	22.94	3.7	500	1000			
B99	29.34	21.81	3.45	500	1000			
B59	23.04	16.96	4.85	600	1000	23.17	17.1	5.62
B64	23.00	17.19	6.5	600	1000			
B73	23.48	17.15	5.5	600	1000			

TABLE V

HIDUMINIUM RR-350 CAST TEST BAR SPECIMENS,
EFFECT OF TEMPERATURE EXPOSURE ON TENSILE PROPERTIES

SPEC. NO.	ULTIMATE STRENGTH	YIELD STRENGTH	ELONGATION	HOLD AND TEST TEMP.	HOLD TIME
A60	38.97	32.21	1.7	300	1000
A105	34.02	27.65	2.7	400	1000
A159	23.06	17.52	7.8	600	1000
*B136	36.06	25.86	2.8	300	1000
*B128	33.10	24.98	2.8	400	1000
*B116	22.59	16.37	4.8	600	1000

* STANDARD HEAT TREATMENT AND AGE PLUS 16 HOURS AT 500°F PRIOR TO TEST EXPOSURE.

TABLE VI

HIDUMINIUM RR-350 COMPONENT CASTINGS
STANDARD AGE
ROOM TEMPERATURE TENSILE PROPERTIES

SPEC. NO.	ULTIMATE KSI	YIELD KSI	ELONGATION %	SPEC. TYPE
2A	37.17	28.79	1.9	Smooth
6A	37.46	29.49	1.2	Smooth
6B	35.45	29.09	1.2	Smooth
AVERAGE	36.69	29.12	1.4	
22	30.44			Notched K_t=3.0
23	32.37			Notched K_t-3.0
24	31.46			Notched K_t=3.0
AVERAGE	31.42			

$\frac{\text{NOTCHED}}{\text{UNNOTCHED}}$ RATIO = .85

TABLE VII

HIDUMINIUM RR-350 COMPONENT CASTINGS,
EFFECT OF TEMPERATURE EXPOSURE ON TENSILE PROPERTIES

SPEC. NO.	ULTIMATE STRENGTH KSI	YIELD STRENGTH KSI	ELONGATION %	HOLD AND TEMP. TEST °F	HOLD TIME (Hrs)
8	31.94	25.99	1.8	300	1000
14	30.09	23.75	2.4	300	1000
57	33.03	26.11	1.7	300	1000
AVERAGE	31.68	25.28	2.0	300	1000
12	25.46	20.01	2.4	400	1000
29	31.84	23.66	6.4	400	1000
71	27.21	20.79	2.8	400	1000
AVERAGE	28.17	21.45	3.9	400	1000
11	21.10	17.53	3.1	500	1000
39	24.44	19.41	2.6	500	1000
72	24.73	19.62	2.8	500	1000
AVERAGE	23.42	18.85	2.8	500	1000
13	15.5	13.12	3.1	600	1000
34	18.57	14.84	3.1	600	1000
70	17.21	13.25	2.6	600	1000
AVERAGE	17.09	13.74	2.92	600	1000
15	25.27	19.62	2.3	400	500
42	27.39	21.35	2.5	400	500
65	27.08	19.99	2.6	400	500
AVERAGE	26.58	20.32	2.5	400	500

TABLE VIII

CH-70 WING SPAR CASTING SPECIMENS,
STANDARD AGE ROOM TEMPERATURE TENSILE PROPERTIES

SPEC. NO.	ULTIMATE KSI	YIELD KSI	ELONGATION %	SPEC. TYPE
C6-1-2	66.16	54.64	7.8	Smooth
C26-1-2	63.90	47.4	10.2	Smooth
C27-1-1	67.85	54.47	10.1	Smooth
AVERAGE	65.97	52.17	9.4	
C5-1-1	70.53			Notched K_t=3.0
C26-1-1	66.79			Notched K_t=3.0
C27-1-1	67.02			Notched K_t=3.0
AVERAGE	68.11			

$\frac{\text{NOTCHED}}{\text{UNNOTCHED}}$ RATIO = 1.03

TABLE IX

CH-70 WING SPAR CASTING SPECIMENS,
EFFECT OF TEMPERATURE EXPOSURE ON TENSILE PROPERTIES

SPEC. NO.	ULTIMATE STRENGTH KSI	YIELD STRENGTH KSI	ELONGATION %	HOLD AND TEMP. TEST °F	HOLD TIME (Hrs)
C6-2-1	58.86	54.24	8.6	300	1000
C26-2-1	59.60	57.59	5.0	300	1000
C27-1-2	55.90	52.80	6.1	300	1000
AVERAGE	57.45	54.87	6.56		
C6-4-1	47.62	46.03	12.2	400	1/2
C26-4-1	47.81	45.78	9.4	400	1/2
C27-3-1	50.3	47.0	2.2*	400	1/2
AVERAGE	48.58	46.27	7.2		
* Fractured at gage mark.					
C6-4-2	36.53	32.96	13.2	400	500
C26-4-2	36.08	32.02	10.0	400	500
C27-3-2	38.92	36.12	8.7	400	500
AVERAGE	37.18	33.70	10.6		
C6-2-2	36.62	32.48	15.6	400	1000
C26-2-2	34.38	30.32	11.9	400	1000
C27-1-2	35.20	30.37	9.7	400	1000
AVERAGE	35.40	31.06	12.4		
C6-3-1	21.21	17.55	18.2	500	1000
C26-3-1	20.77	18.29	21.1	500	1000
C27-2-1	24.92	20.93	10.4	500	1000
AVERAGE	22.30	18.92	16.6		
C6-3-2	10.71	8.54	46	600	1000
C26-3-2	11.14	8.83	28.2	600	1000
C27-2-2	11.17	9.14	35.9	600	1000
AVERAGE	11.0	8.83	36.7		

TABLE X

HIDUMINIUM RR-350 CAST TEST BARS,
NOTCHED (K_t=3.0) RUPTURE TESTS

SPECIMEN NO.	TEST TEMPERATURE °F	STRESS KSI	HOURS TO RUPTURE
B29	300	28	1868 Did Not Fail
B69	400	23	682.2
B100	500	15.5	561.6
B67	600	7	1110.3

TABLE XI

TIME IN HOURS VS. TOTAL SPECIMEN DEFORMATION IN PERCENT

MATERIAL:	Hiduminium RR-350	Vendor "A" Cast Test Bar Specimens		
TEMPERATURE:	400°F	400°F	600°F	600°F
STRESS KSI:	23.0	16.0	7.5	3.5
SPECIMEN TIME (HRS)	A72	A141	A66	A114
0.01	0.17	0.19	0.09	0.04
0.02	0.31	0.20	0.10	0.04
0.05	0.35	0.20	0.12	0.04
0.1	0.38	0.22	0.17	0.04
0.2	0.40	0.23	0.17	0.04
0.5	0.43	0.23	0.17	0.04
1.0	0.47	0.23	0.17	0.04
2.0	0.52	0.23	0.17	0.04
5.0	0.60	0.24	0.17	0.05
10.0	0.67	0.24	0.17	0.05
20.0	0.73	0.27	0.17	0.05
50.0	0.84	0.27	0.20	0.06
100.0	0.92	0.31	0.23	0.06
200.0	1.03	0.32	0.26	0.08
500.0	1.17	0.32	0.44	0.12
1000.0	1.33	0.34	0.93	0.21

TABLE XII

MATERIAL:	Hiduminium RR-350	Vendor "B" Cast Test Bar Specimens		
TEMPERATURE:	300°F	300°F	500°F	500°F
STRESS KSI:	25.0	23.0	14.0	8.0
SPECIMEN TIME (HRS)	B85	B9	B74	B34
0.01	0.16	0.19	0.14	0.06
0.02	0.19	0.19	0.15	0.06
0.05	0.20	0.19	0.15	0.06
0.1	0.21	0.19	0.15	0.06
0.2	0.22	0.19	0.15	0.06
0.5	0.23	0.19	0.16	0.06
1.0	0.23	0.20	0.17	0.06
2.0	0.24	0.21	0.18	0.06
5.0	0.25	0.22	0.18	0.07
10.0	0.26	0.23	0.20	0.07
20.0	0.29	0.24	0.22	0.07
50.0	0.33	0.26	0.25	0.08
100.0	0.35	0.27	0.30	0.10
200.0	0.51	0.30	0.35	0.11
500.0	0.57	0.34	0.48	0.16
1000.0	0.60	0.38	0.72	0.18

TABLE XIII

MATERIAL: Hiduminium RR-350 Vendor "B" Cast Test Bar Specimens
TEMPERATURE: 400°F

STRESS KSI	25.66	25.0	23.0	23.0	20.0	17.0	16.0	16.0	16.0
SPECIMEN TIME (HRS)	B68	B53	B120	B24	B4	B46	B1	B16	B144
0.01	0.45	0.45	0.36	0.42	0.21	0.16	0.12	0.14	0.18
0.02	0.54	0.52	0.68	0.46	0.23	0.16	0.12	0.14	0.18
0.05	0.64	0.58	0.87	0.51	0.25	0.17	0.12	0.14	0.18
0.1	0.71	0.63	0.87	0.54	0.26	0.17	0.12	0.15	0.18
0.2	0.76	0.67	0.87	0.58	0.28	0.17	0.12	0.15	0.18
0.5	0.86	0.74	0.88	0.63	0.30	0.18	0.13	0.15	0.18
1.0	0.92	0.81	0.98	0.67	0.31	0.18	0.14	0.16	0.18
2.0	1.01	0.87	0.99	0.73	0.34	0.18	0.14	0.17	0.19
5.0	1.16	0.97	1.03	0.81	0.38	0.19	0.14	0.18	0.21
10.0	1.29	1.06	1.07	0.88	0.42	0.20	0.14	0.20	0.23
20.0	1.44	1.19	1.09	0.98	0.45	0.22	0.15	0.21	0.23
50.0	1.72	1.45	1.17	1.14	0.51	0.22	0.17	0.22	0.24
100.0	2.08	1.82	1.24	1.30	0.54	0.25	0.18	0.23	0.28
200.0	Fracture @143 Hrs	Fracture @134 Hrs	Fracture @158Hrs	1.61	0.58	0.28	0.22	0.25	0.28
500.0				2.22	0.63	Fracture @332 Hrs	0.23	0.27	0.29
1000.0				Fracture @574 Hrs	0.74		0.23	0.30	0.30

TABLE XIV

MATERIAL: Hiduminium RR-350 Vendor "B" Cast Test Bar Specimens
TEMPERATURE: 600°F
STRESS KSI: 7.0 7.5 7.0 3.5 3.5 4.0 4.0

SPECIMEN TIME (HRS)	B13	B60	B140	B10	B28	B78	B124
0.01	0.09	0.07	0.07	0.03	0.03	0.05	0.06
0.02	0.09	0.07	0.07	0.03	0.04	0.05	0.06
0.05	0.09	0.08	0.08	0.03	0.04	0.05	0.06
0.1	0.09	0.08	0.08	0.03	0.04	0.05	0.06
0.2	0.10	0.08	0.08	0.03	0.04	0.05	0.06
0.5	0.11	0.09	0.08	0.03	0.04	0.06	0.06
1.0	0.11	0.10	0.09	0.04	0.04	0.06	0.06
2.0	0.12	0.13	0.09	0.04	0.04	0.06	0.07
5.0	0.14	0.14	0.11	0.04	0.04	0.06	0.09
10.0	0.16	0.17	0.12	0.04	0.05	0.06	0.09
20.0	0.19	0.20	0.14	0.04	0.05	0.07	0.10
50.0	0.32	0.30	0.19	0.06	0.06	0.09	0.13
100.0	0.41	0.43	0.27	0.07	0.06	0.13	0.16
200.0	0.56	0.70	0.38	0.11	0.06	0.25	0.19
500.0	1.15	Fracture @446 Hrs	0.80	0.20	0.15	0.36	0.27
1000.0	Fracture @815 Hrs		Fracture @871 Hrs	0.25	0.20	0.40	0.42

TABLE XV

MATERIAL: Hiduminium RR-350 Component Parts Specimens

TEMPERATURE:	300°F	300°F	500°F	500°F
STRESS KSI	26.0	23.0	12.0	8.0
SPECIMEN TIME (HRS)	30	28	37	53
0.01	0.37	0.29	0.36	0.07
0.02	0.39	0.30	0.36	0.07
0.05	0.41	0.30	0.38	0.07
0.1	0.42	0.30	0.39	0.07
0.2	0.44	0.30	0.40	0.07
0.5	0.49	0.30	0.43	0.07
1.0	0.50	0.30	0.45	0.07
2.0	0.53	0.30	0.46	0.08
5.0	0.55	0.34	0.51	0.09
10.0	0.58	0.34	0.53	0.09
20.0	0.62	0.35	0.58	0.09
50.0	0.73	0.38	0.63	0.09
100.0	0.84	0.41	0.69	0.13
200.0	0.88	0.49	0.72	0.16
500.0	0.96	0.45	0.77	0.21
1000.0	1.02	0.54	0.77	0.27

TABLE XVI

MATERIAL: Hiduminium RR-350 Component Parts Specimens
TEMPERATURE: 400°F

STRESS KSI:	23.0	20	16	16	15	15
SPECIMEN TIME (HRS)	21	41	61	27	45	56
0.01	0.61	0.14	0.21	0.19	0.07	0.10
0.02	0.72	0.31	0.21	0.19	0.07	0.10
0.05	0.83	0.40	0.21	0.20	0.07	0.10
0.1	0.94	0.44	0.21	0.21	0.07	0.10
0.2	1.10	0.50	0.22	0.24	0.08	0.10
0.5	1.47	0.59	0.24	0.24	0.08	0.11
1.0	Fracture @0.51 Hrs	0.68	0.24	0.29	0.08	0.12
2.0		0.84	0.26	0.29	0.11	0.13
5.0		1.04	0.29	0.34	0.12	0.13
10.0		Fracture @5.3 Hrs	0.31	0.38	0.12	0.13
20.0			0.36	0.44	0.12	0.13
50.0			0.38	0.46	0.12	0.18
100.0			0.42	0.51	0.18	0.20
200.0			0.48	0.54	0.20	0.21
500.0			1.11	0.60	0.26	0.35
1000.0				Fracture @694 Hrs	0.26	0.39

TABLE XVII

MATERIAL: Hiduminium RR-350 Component Parts Specimens
TEMPERATURE: 600°F
STRESS KSI: 7.0 7.0 6.0 4.0 3.5 3.0

SPECIMEN TIME (HRS)	26	43	59	50	32	51
0.01	0.08	0.02	0.03	0.01	0.01	0.04
0.02	0.09	0.02	0.03	0.01	0.01	0.04
0.05	0.09	0.02	0.03	0.01	0.01	0.04
0.1	0.09	0.02	0.03	0.01	0.01	0.06
0.2	0.09	0.02	0.03	0.01	0.01	0.06
0.5	0.26	0.02	0.04	0.02	0.01	0.06
1.0	0.26	0.02	0.04	0.02	0.01	0.07
2.0	0.26	0.03	0.04	0.02	0.01	0.07
5.0	Controller	0.05	0.05	0.02	0.01	0.07
10.0	Caused Failure @	0.09	0.05	0.02	0.01	0.07
20.0	3.5	0.16	0.05	0.03	0.02	0.07
50.0		0.32	0.13	0.01	0.02	0.07
100.0		0.73	0.20	0.07	0.03	0.07
200.0		1.74	Fracture @175 Hrs	0.10	0.07	0.09
500.0		Fracture @208 Hrs		0.43	0.11	0.11
1000.0				1.18	0.15	0.11

TABLE XVIII

TIME IN HOURS VS. TOTAL SPECIMEN DEFORMATION IN PERCENT

MATERIAL: CH-70
TEMPERATURE: 400°F

STRESS KSI:	27.0	23.0	23.0	23.0	16.0	16.0	16.0
SPECIMEN TIME (HRS)	C26-8-1	C6-8-1	C27-8-1	C27-8-2	C6-12-1	C26-8-2	C6-12-1
0.01	0.30	0.18	0.39	0.20	0.27	0.13	0.09
0.02	0.30	0.18	0.39	0.20	0.30	0.13	0.10
0.05	0.30	0.18	0.40	0.20	0.37	0.13	0.10
0.1	0.30	0.18	0.42	0.20	0.47	0.13	0.10
0.2	0.30	0.18	0.44	0.20	0.54	0.13	0.10
0.5	0.31	0.19	0.47	0.20	0.68	0.14	0.10
1.0	0.32	0.19	0.47	0.22	0.83	0.14	0.10
2.0	0.32	0.19	0.48	0.22	0.95	0.14	0.10
3.0	0.34	0.20	0.52	0.23	Fracture @3.7 Hrs	0.14	0.11
10.0	0.38	0.21	0.53	0.24		0.15	0.11
20.0	0.41	0.22	0.54	0.25		0.15	0.11
50.0	0.49	0.26	0.61	0.30		0.20	0.12
100.0	Fracture @93 Hrs	0.31	0.64	0.30		0.21	0.13
200.0		Failed in Grip @127 Machining Fault	0.71	0.47		0.25	0.16
500.0			Fracture @379 Hrs	Fracture @225 Hrs		0.29	0.23
1000.0						0.34	0.30

TABLE XIX

MATERIAL: CH-70
TEMPERATURE: 600°F

STRESS KSI:	4.0	4.0	3.5	3.0	3.0
SPECIMEN TIME (HRS)	C6-8-2	C6-12-2	C26-12-2	C27-12-1	C27-12-2
0.01	0.05	0.05	0.02	0.08	0.04
0.02	0.05	0.05	0.02	0.08	0.04
0.05	0.05	0.05	0.02	0.08	0.04
0.1	0.05	0.05	0.02	0.08	0.04
0.2	0.05	0.05	0.02	0.08	0.04
0.5	0.05	0.05	0.02	0.08	0.04
1.0	0.05	0.07	0.03	0.08	0.05
2.0	0.05	0.08	0.03	0.08	0.05
5.0	0.05	0.08	0.04	0.11	0.05
10.0	0.06	0.08	0.06	0.11	0.05
20.0	0.10	0.12	0.08	0.11	0.06
50.0	0.21	0.18	0.14	0.16	0.13
100.0	0.40	0.32	0.25	0.22	0.18
200.0	0.96	0.60	0.57	0.46	0.41
500.0	3.25	2.45	2.29	1.37	1.29
1000.0	Fracture @546 Hrs	Fracture @502 Hrs	Fracture @521 Hrs	Fracture @882 Hrs	Fracture @556 Hrs

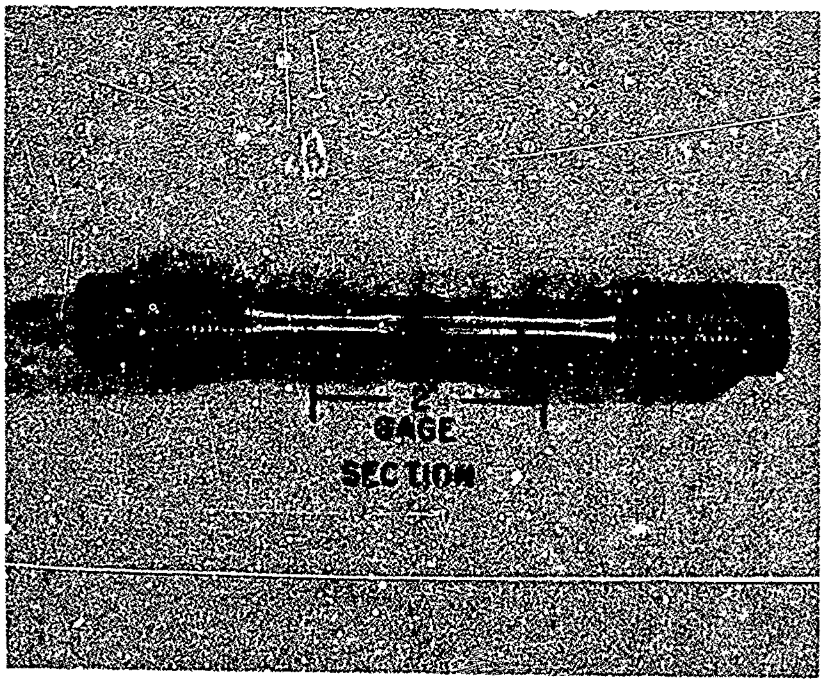

FIGURE 1
SMOOTH CAST TEST BAR SPECIMEN

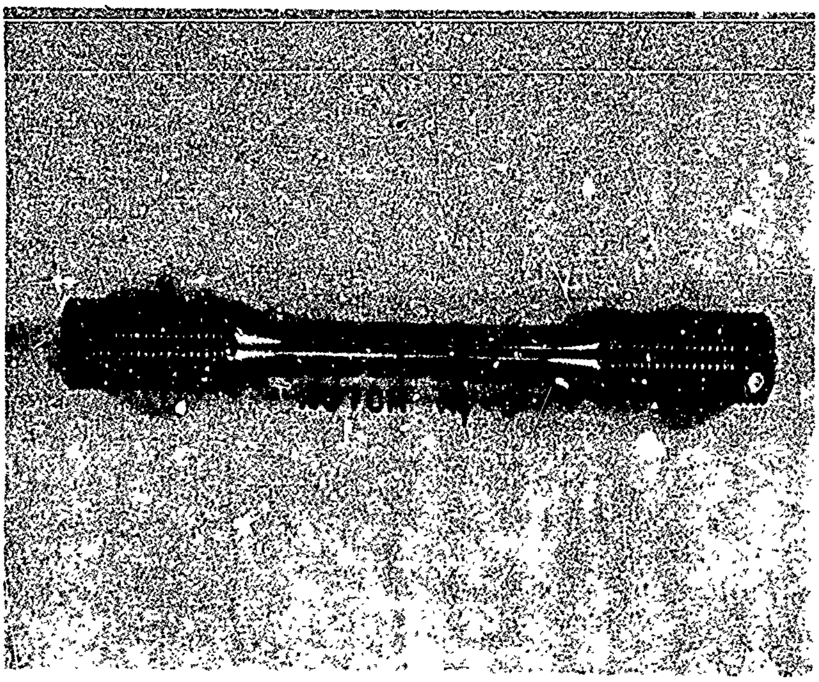

FIGURE 2
NOTCHED (K_t=3.0) CAST TEST BAR SPECIMEN

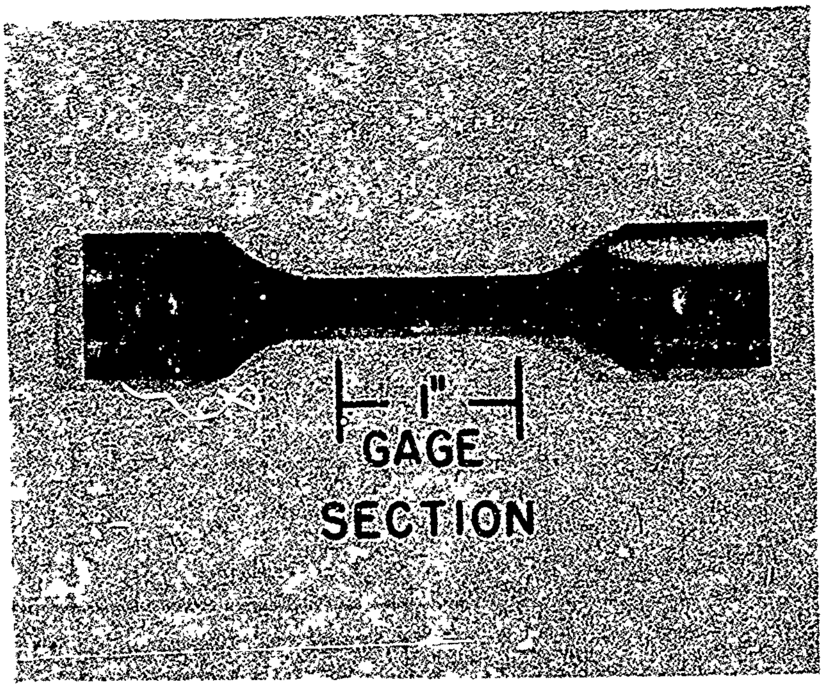

FIGURE 3
COMPONENT PART FLAT SPECIMEN

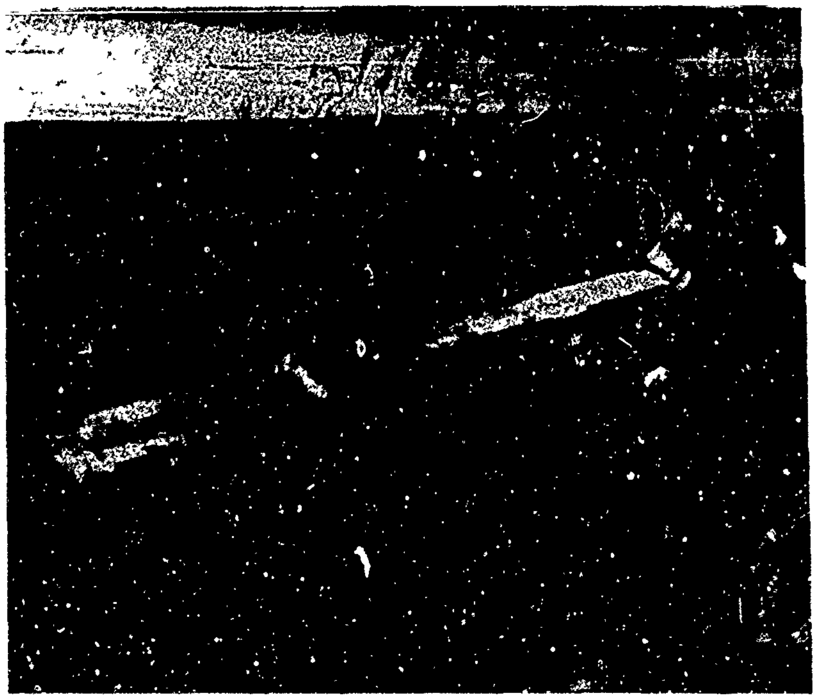

FIGURE 4
CH-70 WING SPAR CASTING SPECIMEN

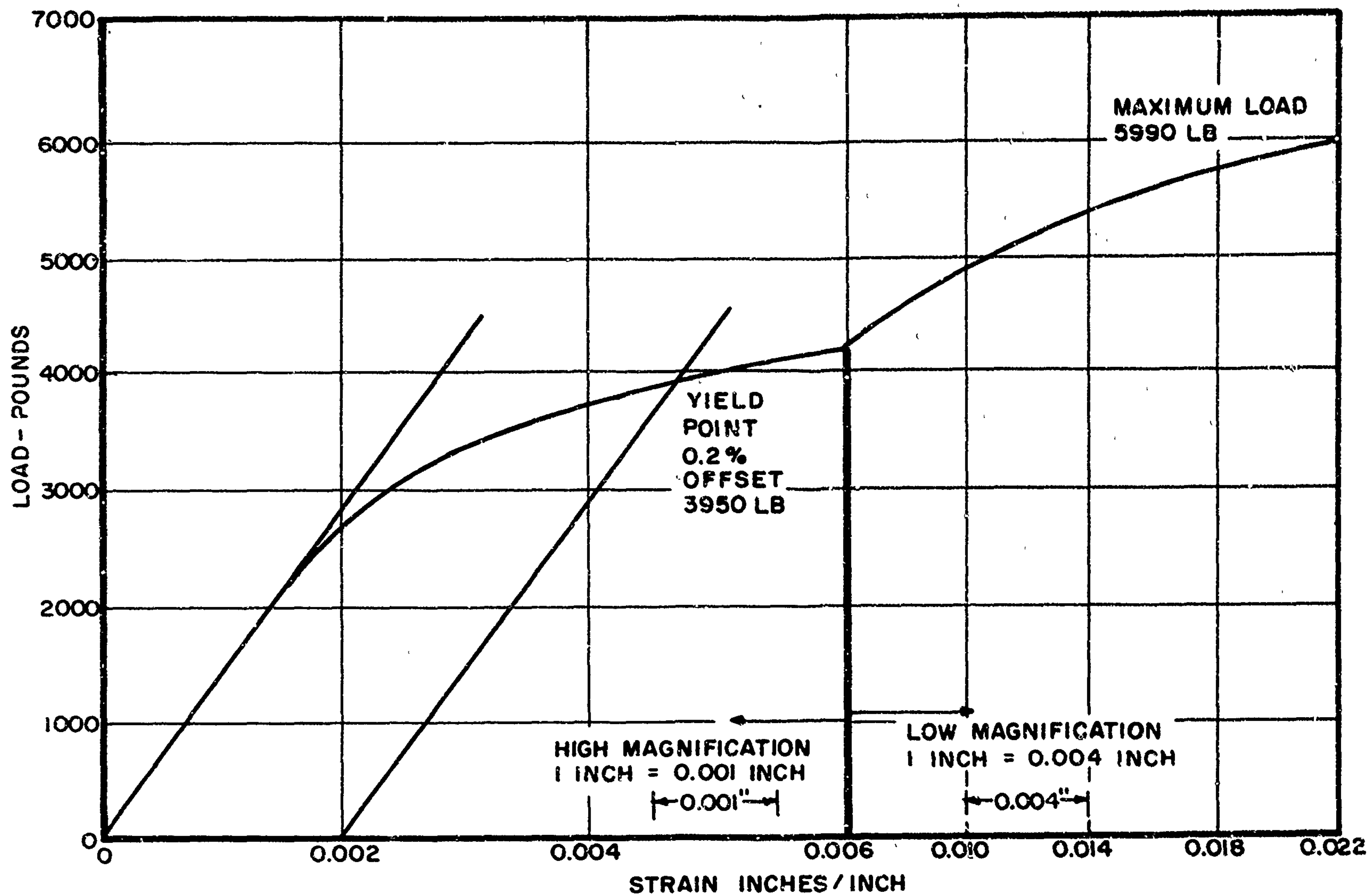

FIGURE 5. TYPICAL LOAD-STRAIN RECORD FOR RR-350 CAST TEST BAR SPECIMEN A-23 550°F AGE TEMPERATURE

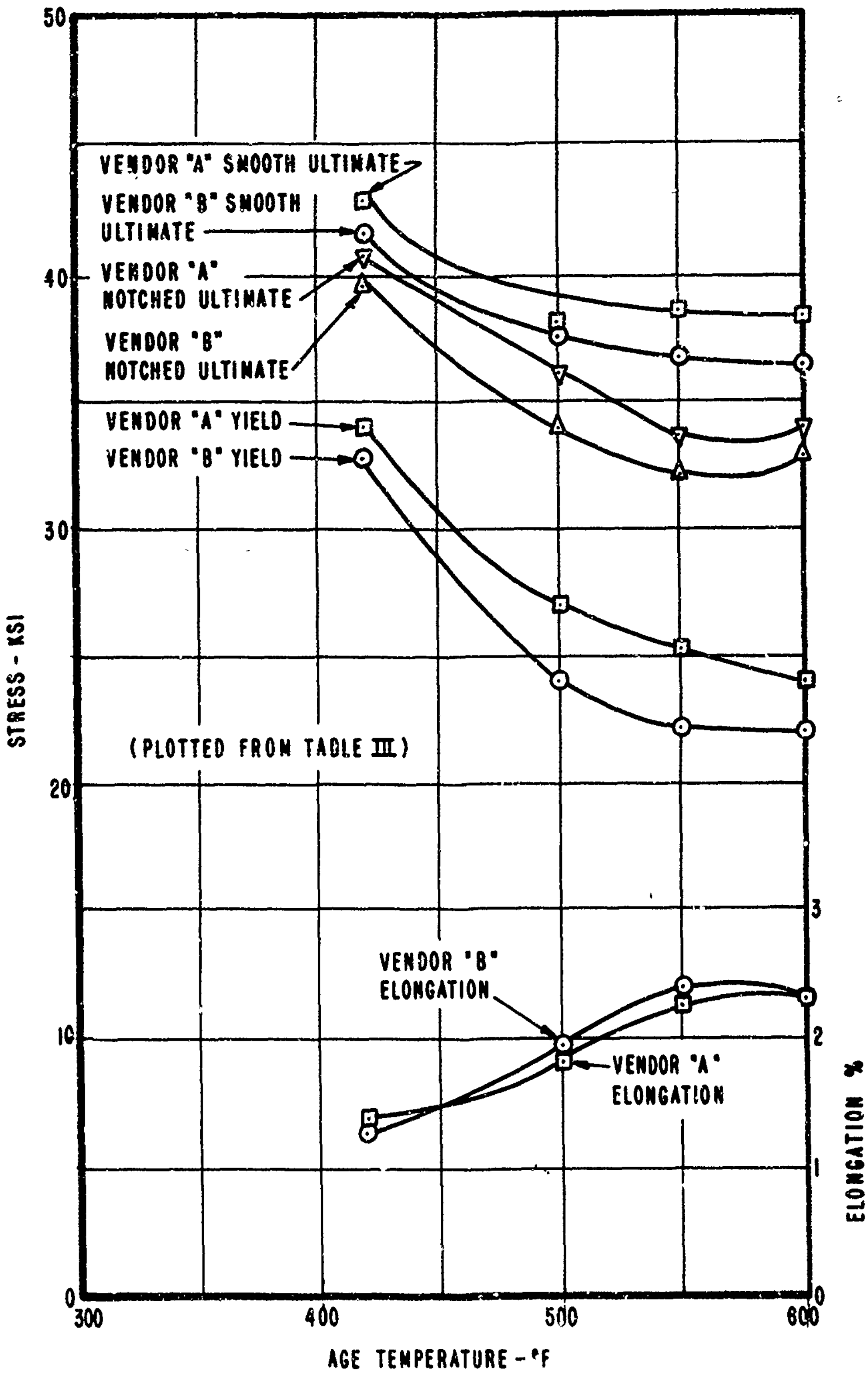

FIGURE 6. HIDUMINIUM RR-350 CAST TEST BAR SPECIMENS, EFFECT OF AGE TEMPERATURE ON TENSILE PROPERTIES

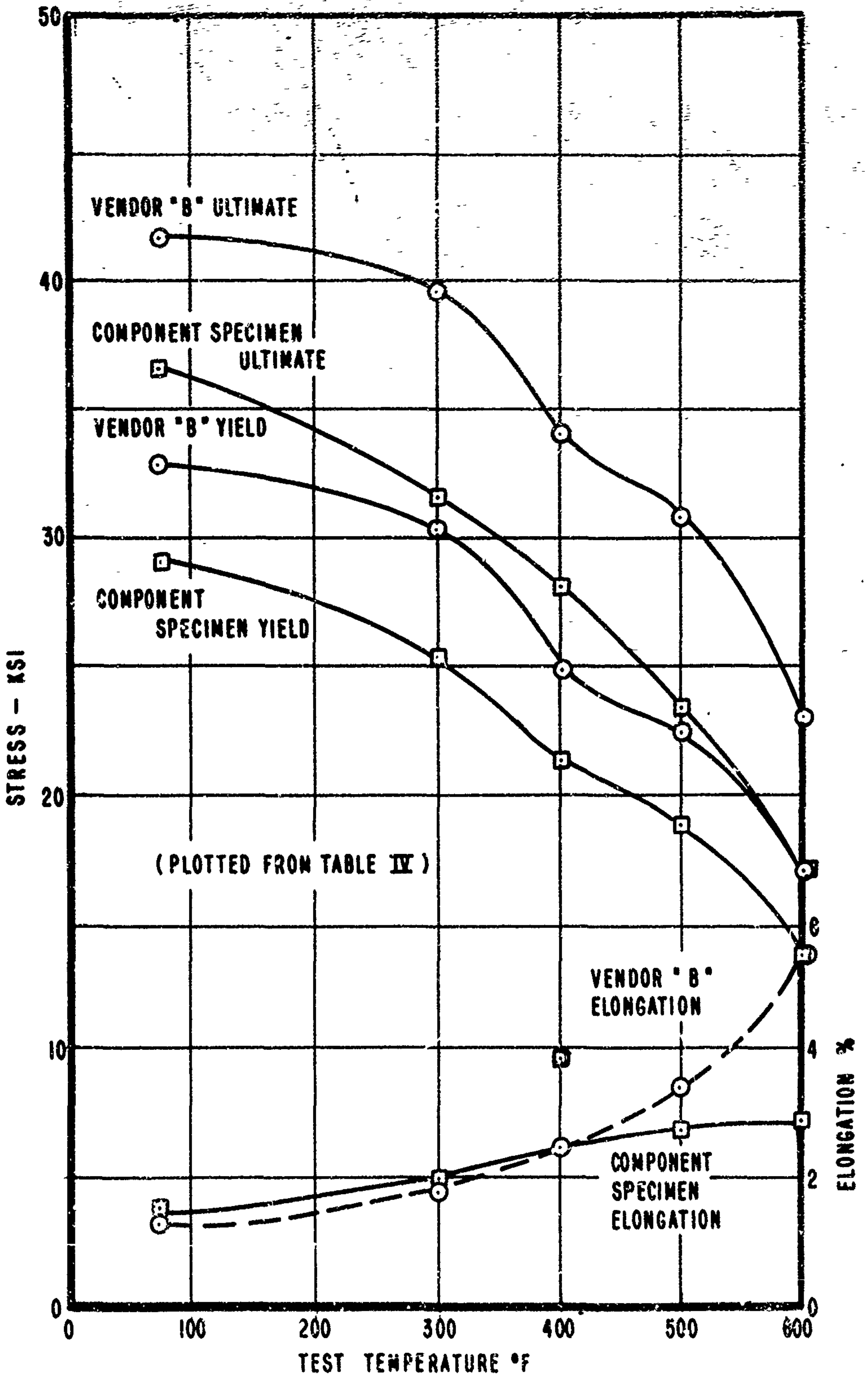

FIGURE 7. HIDUMINIUM RR-350 CAST TEST BAR SPECIMENS, EFFECT OF 1000-HOUR EXPOSURE ON TENSILE PROPERTIES

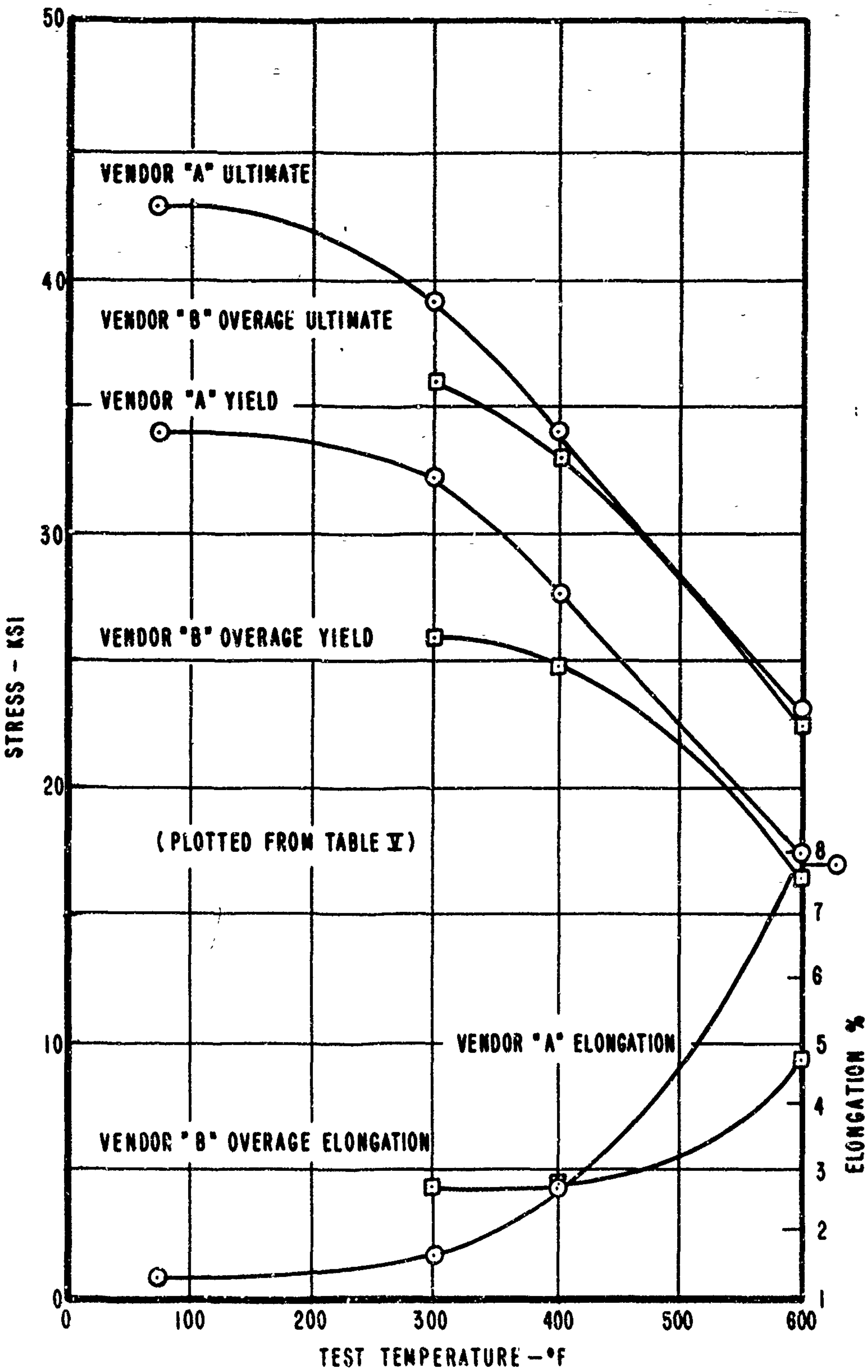

FIGURE 8. HIDUMINIUM RR-350 CAST TEST BAR SPECIMENS, EFFECT OF 1000-HOUR EXPOSURE ON TENSILE PROPERTIES

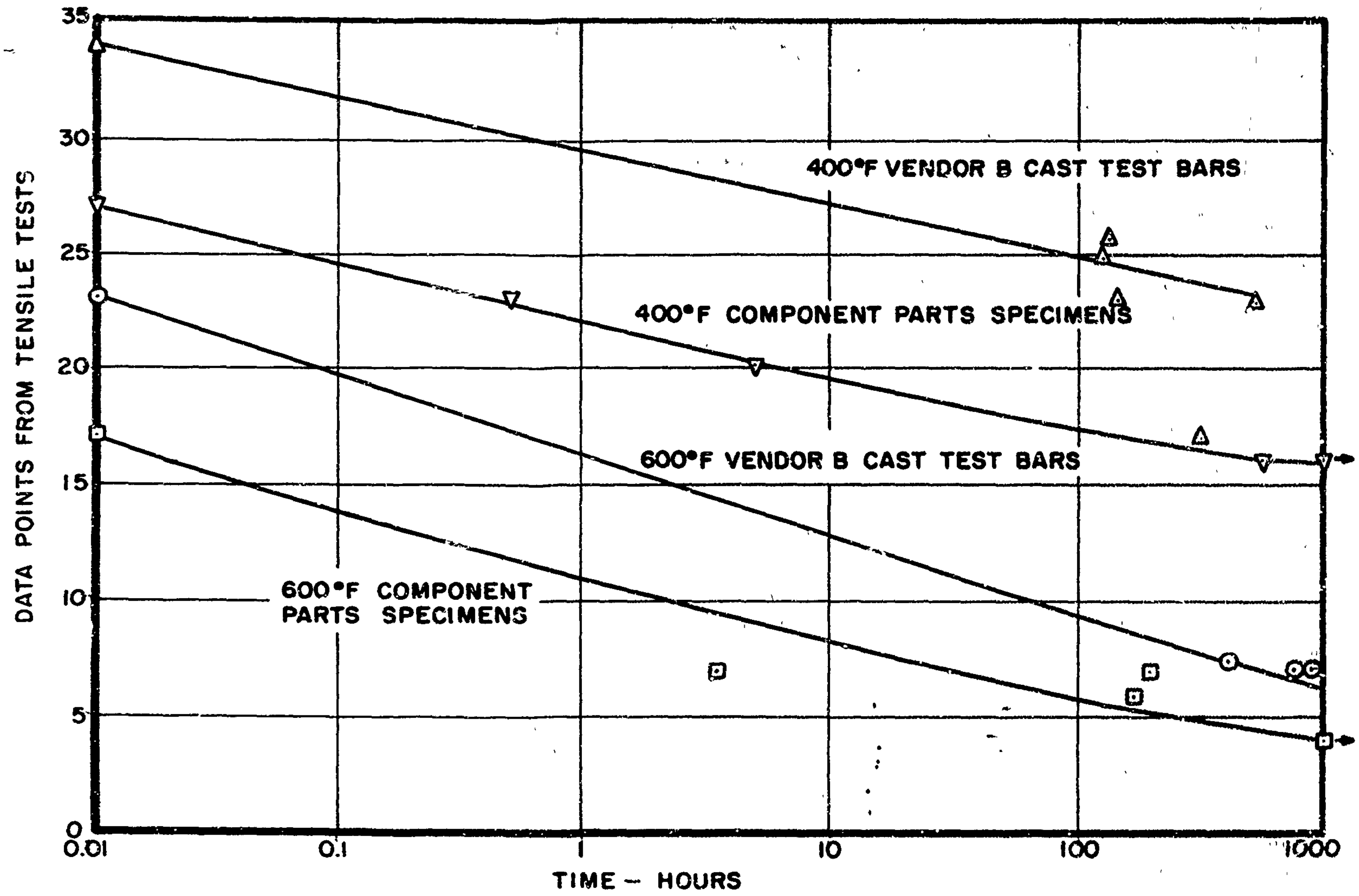

FIGURE 9. HIDUMINIUM RR-350, STRESS VS. RUPTURE TIME

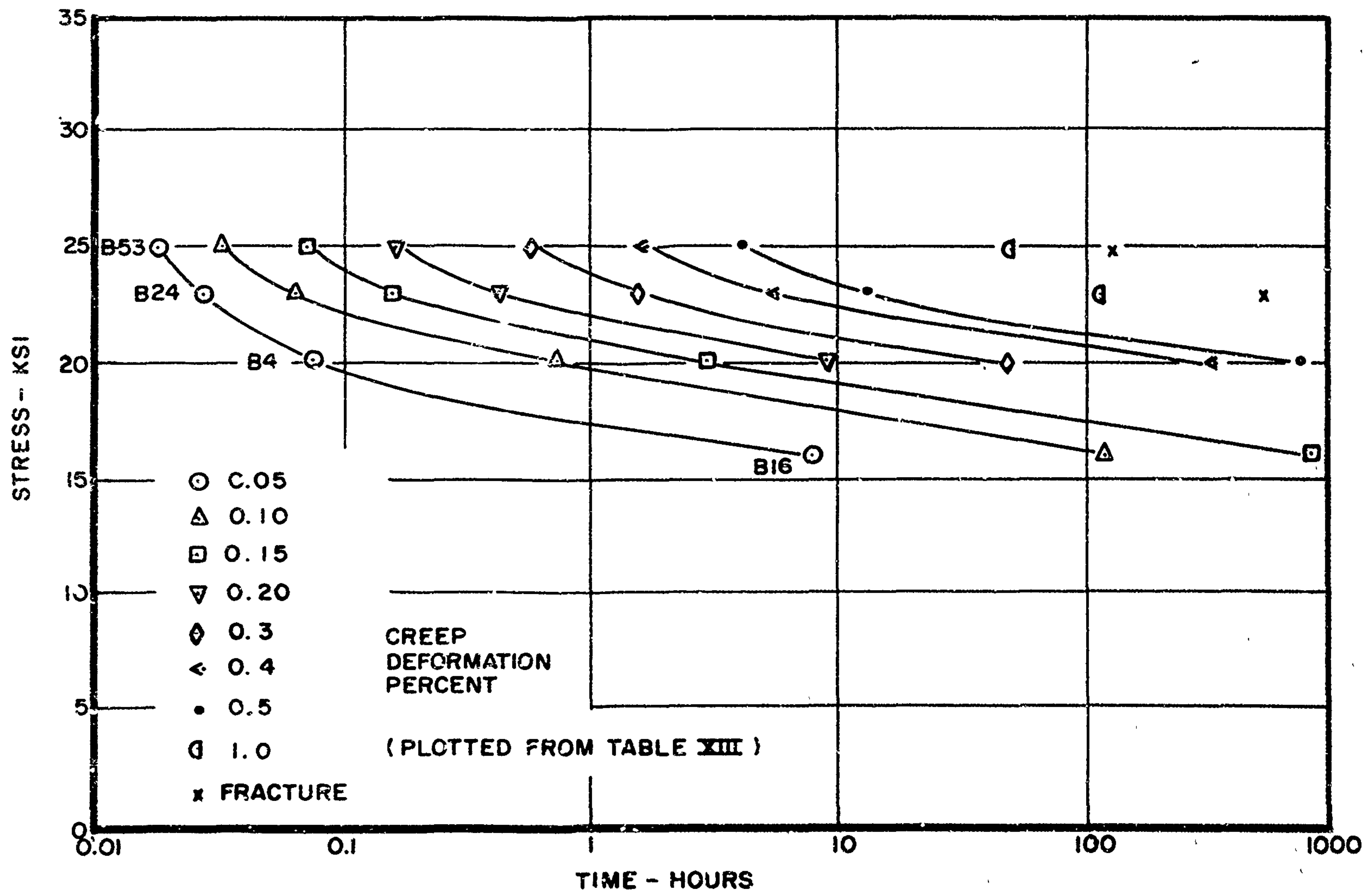

FIGURE 10. HIDUMINIUM RR-350 VENDOR B CAST TEST BAR SPECIMENS, 400°F TIME TO DEFORMATION

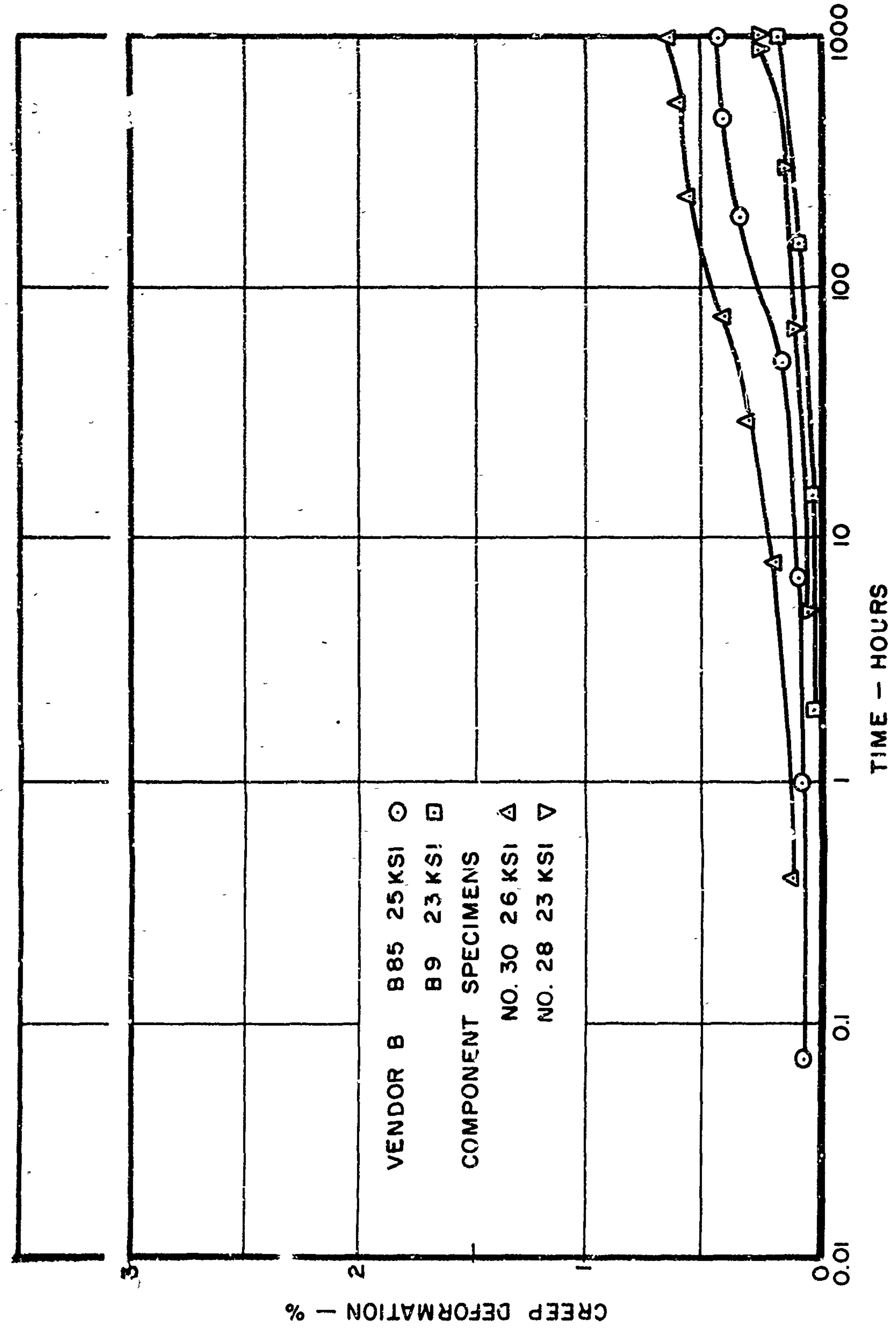

FIGURE 11. HIDUMINIUM RR-350, 300°F CREEP DEFORMATION VS. TIME

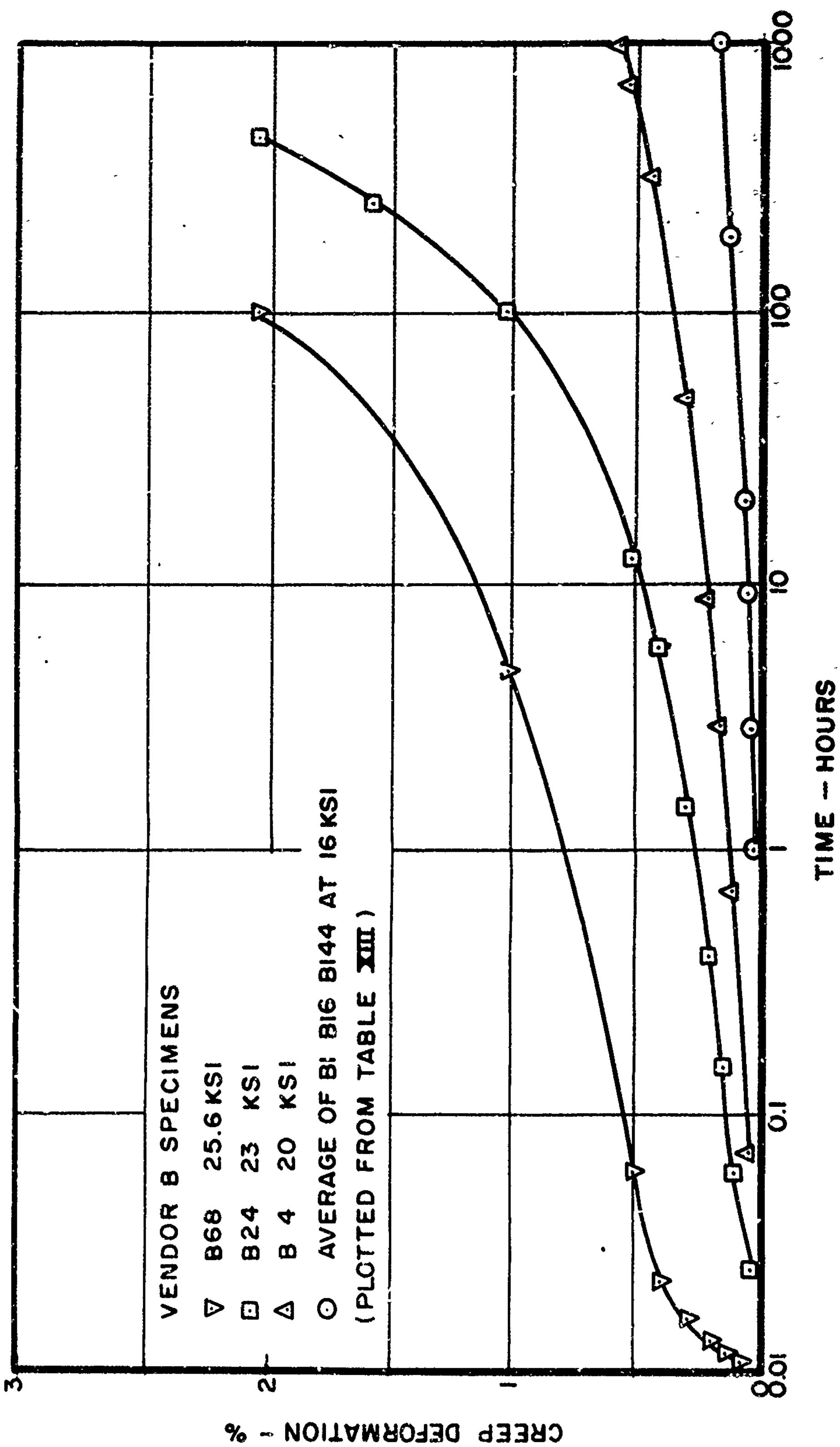

FIGURE 12. HIDUMINIUM RR-350, 400°F CREEP DEFORMATION VS. TIME

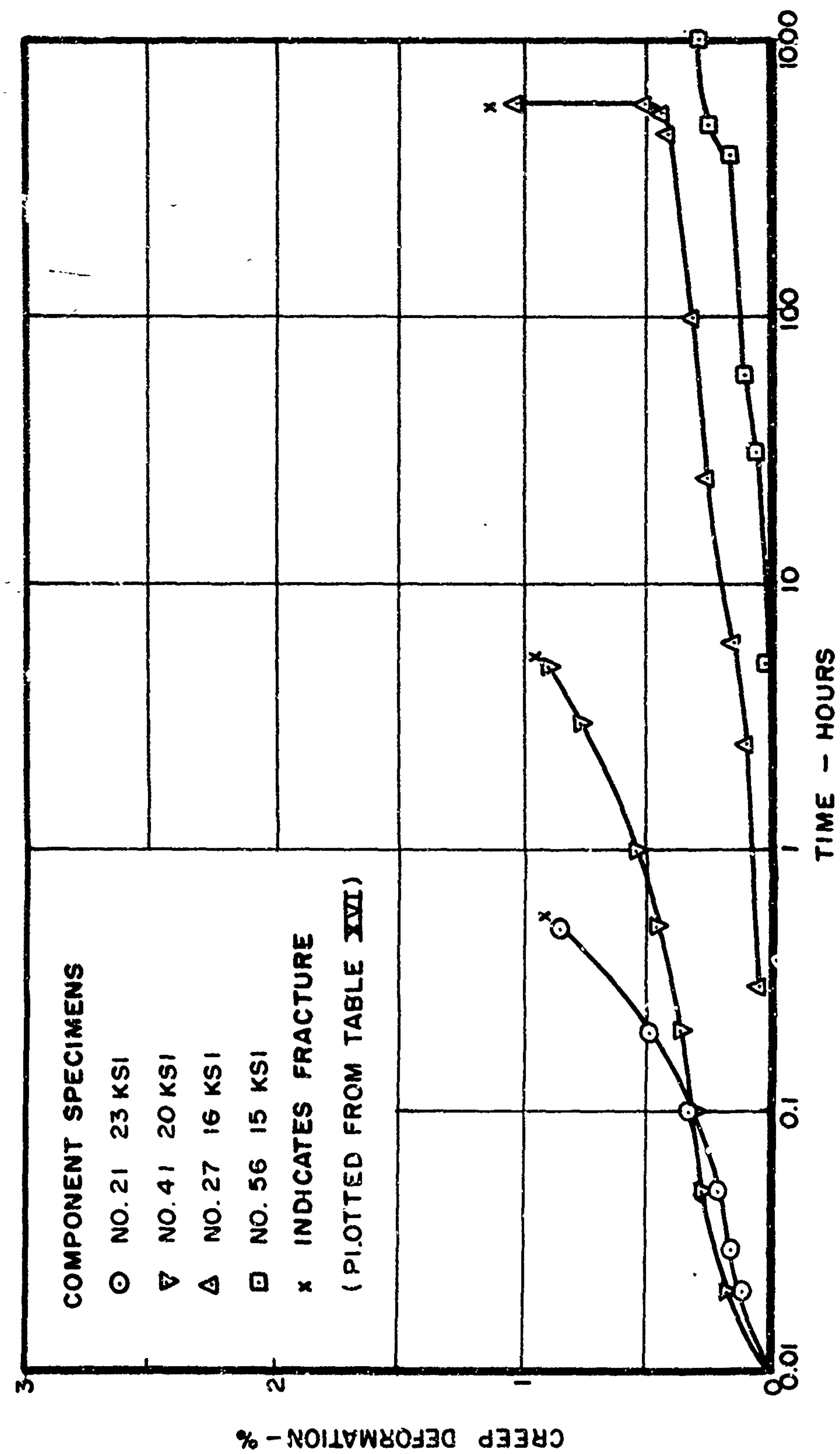

FIGURE 13. HIDUMINIUM RR-350, 400°F CREEP DEFORMATION VS. TIME

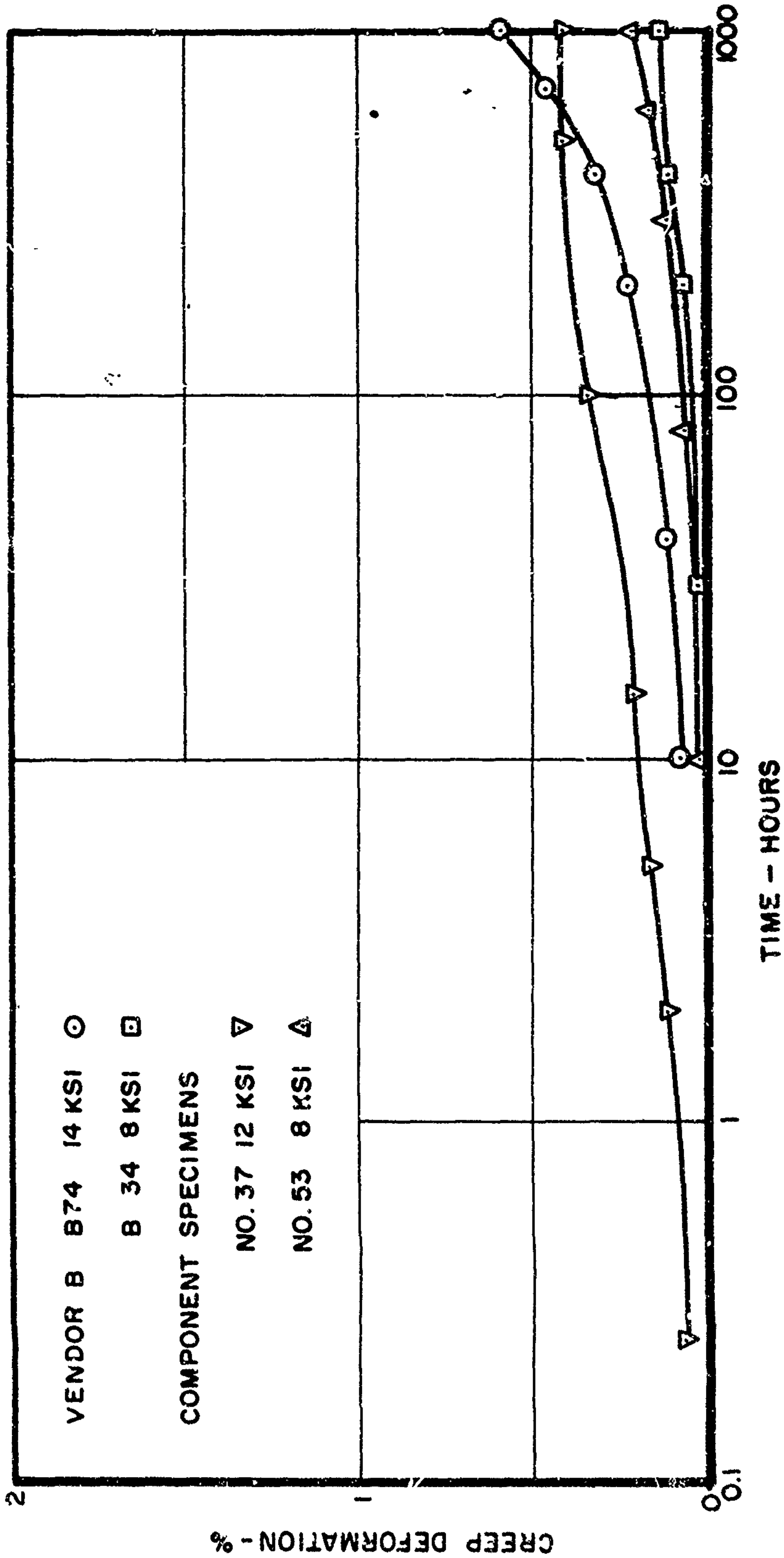

FIGURE 14. HIDUMINIUM RR-350, 500°F CREEP DEFORMATION VS. TIME

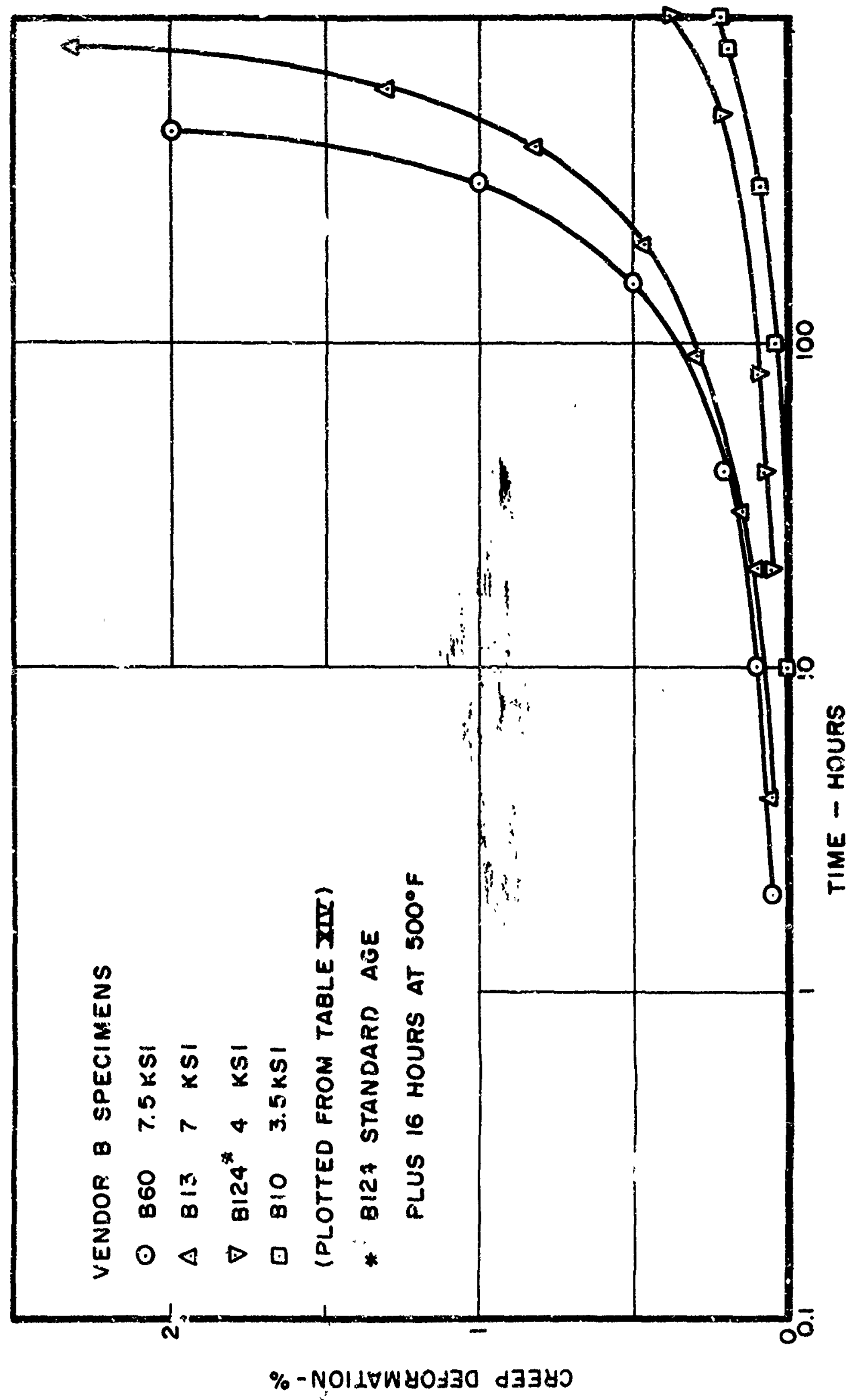

FIGURE 15. HIDUMINIUM RR-350, 600°F CREEP DEFORMATION VS. TIME

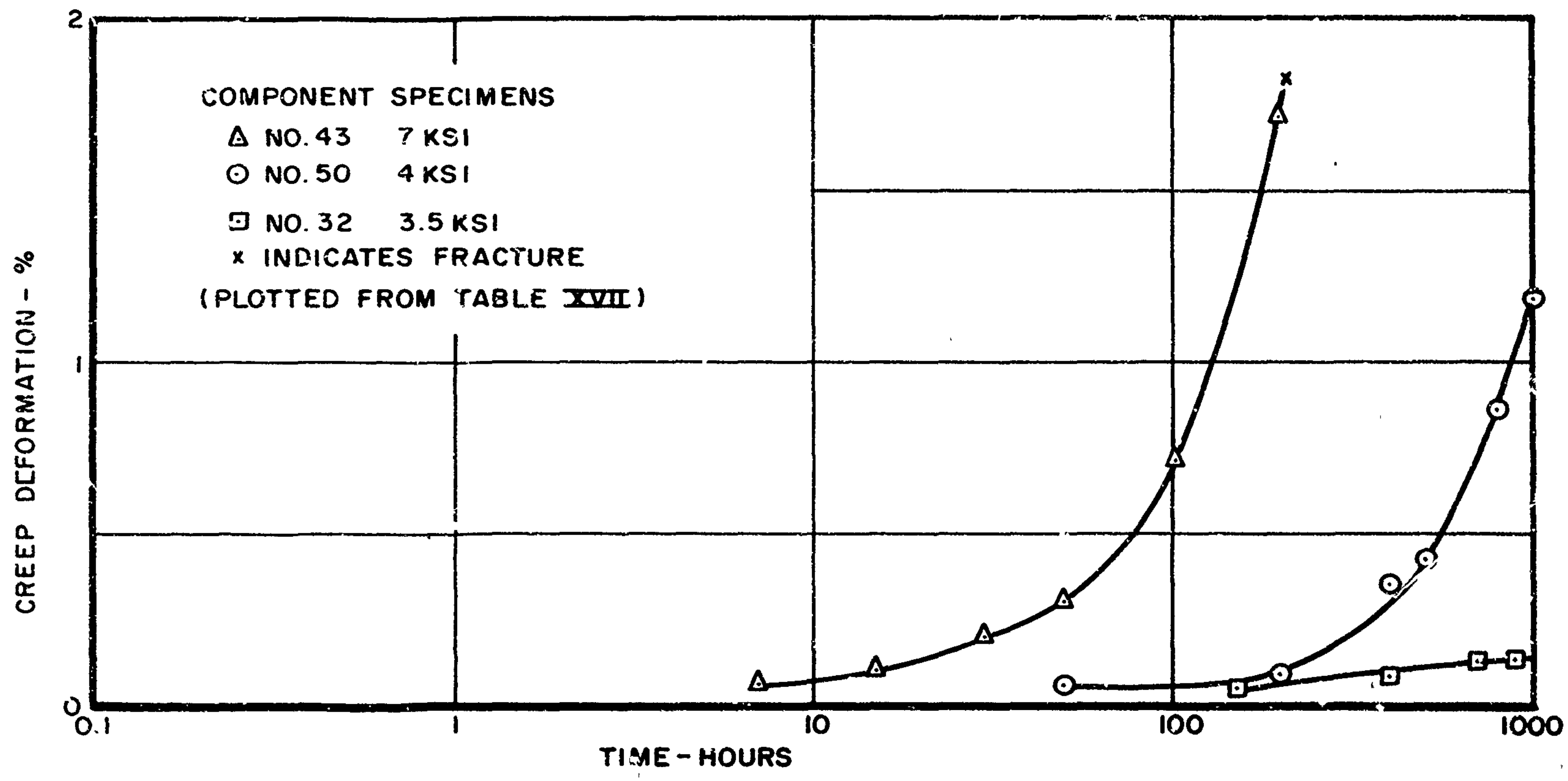

FIGURE 16. HIDUMINIUM RR-350, 600° F CREEP DEFORMATION VS. TIME

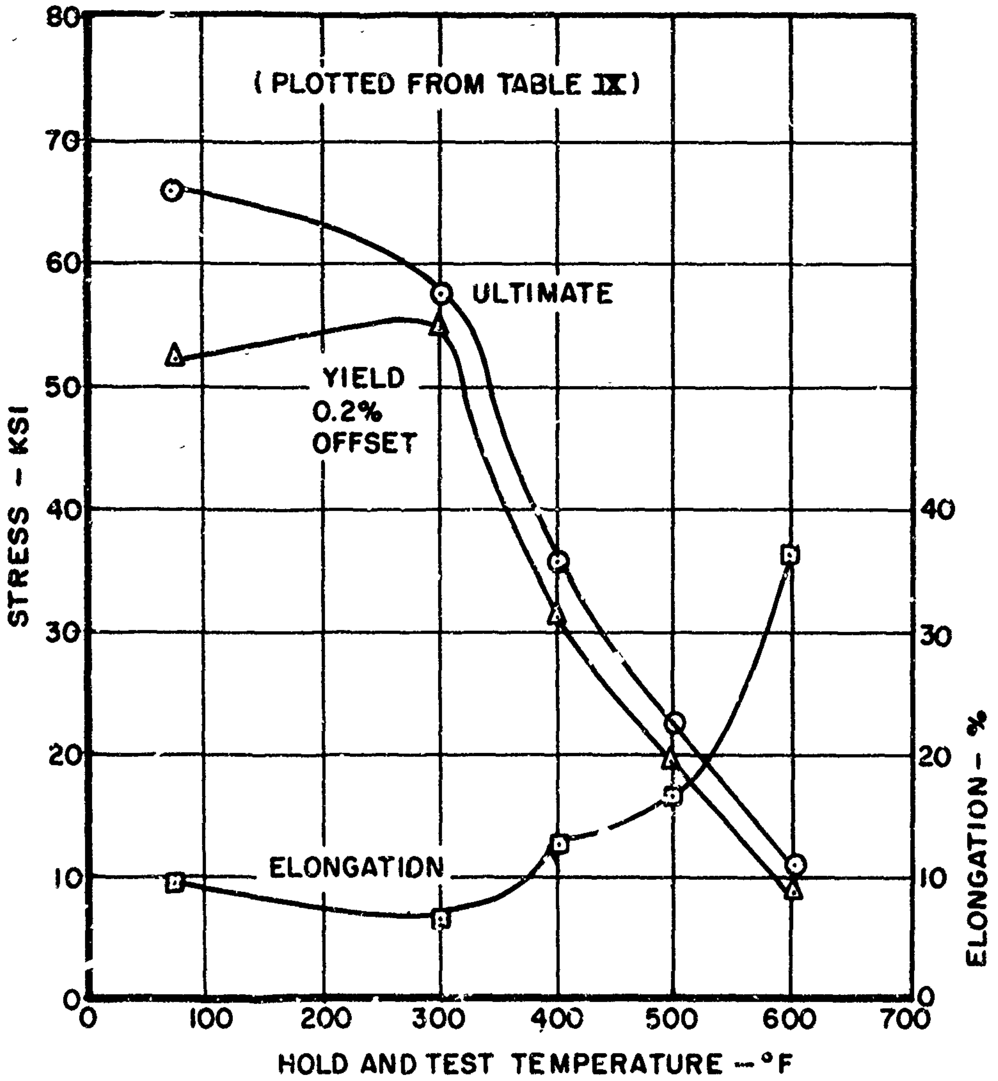

FIGURE 17. CH-70 WING SPAR CASTING SPECIMENS, EFFECT OF 1000-HOUR EXPOSURE ON TENSILE PROPERTIES

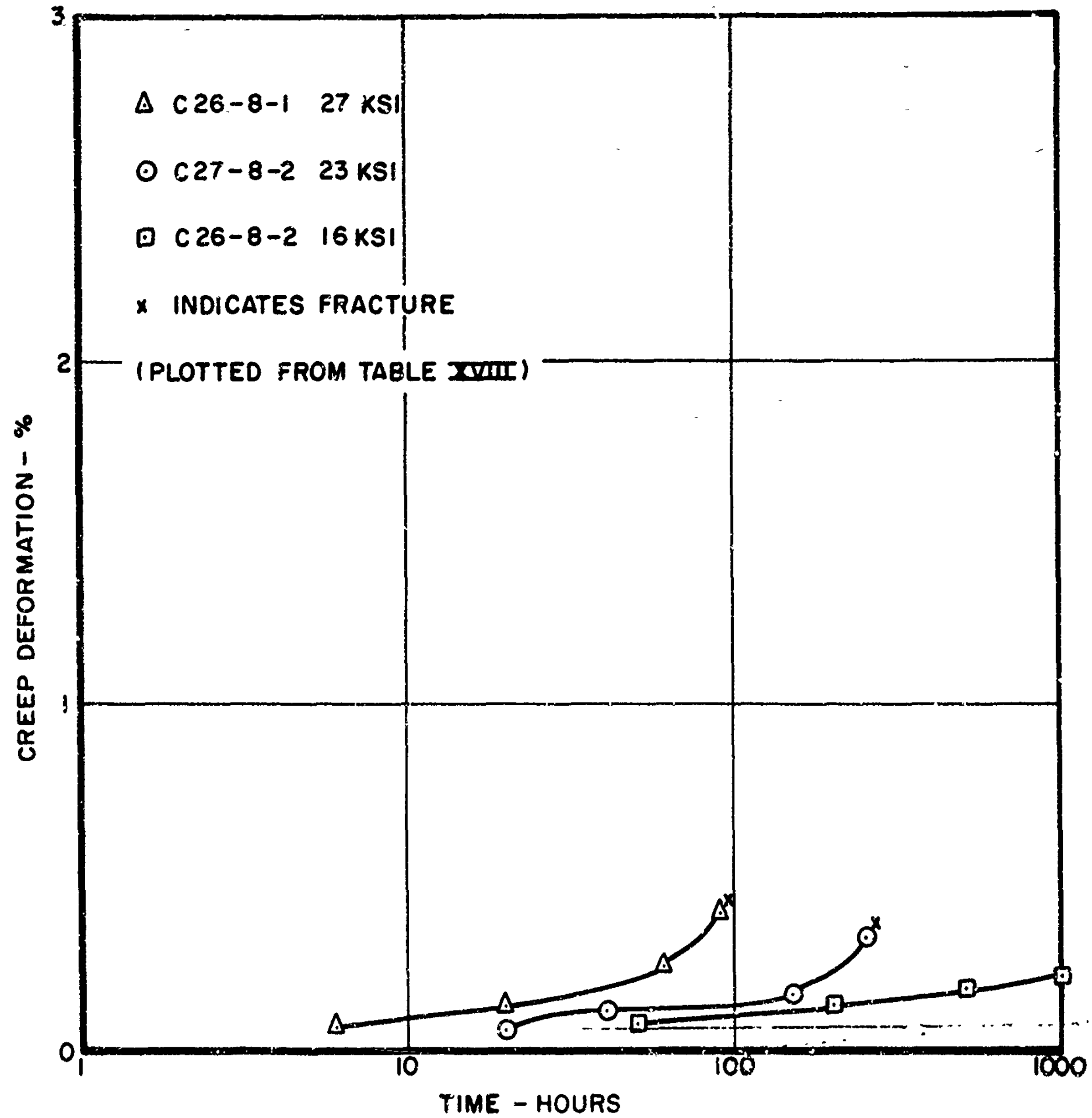

FIGURE 18. CH-70 WING SPAR CASTING SPECIMENS, 400°F CREEP DEFORMATION VS. TIME

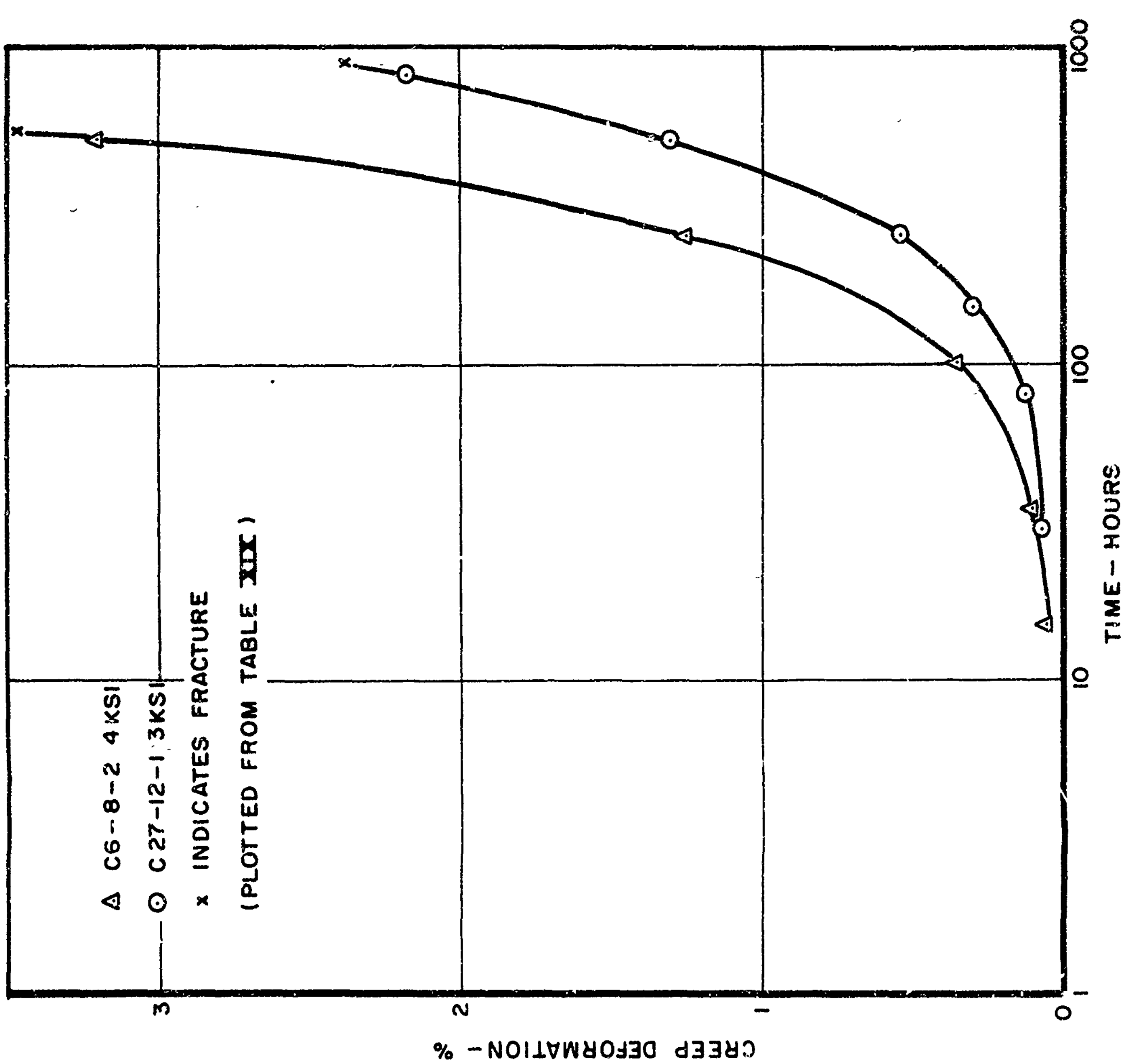

FIGURE 19. CH-70 WING SPAR CASTING SPECIMENS, 600°F CREEP DEFORMATION VS. TIME HIDUMINIUM RR-350 and CH-70

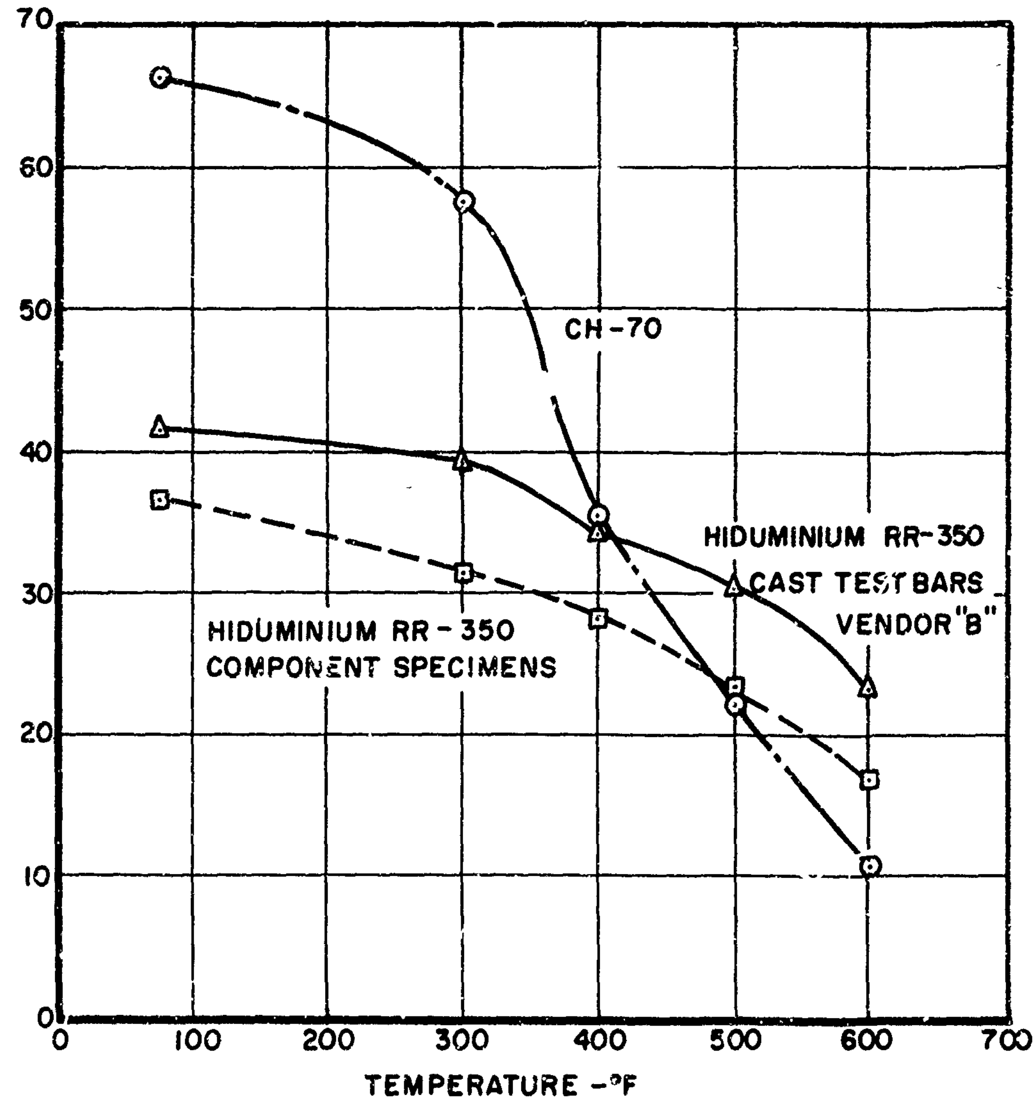

FIGURE 20. COMPARISON OF ULTIMATE TENSILE STRENGTH VS. TEMPERATURE FOR 1000-HOUR EXPOSURE

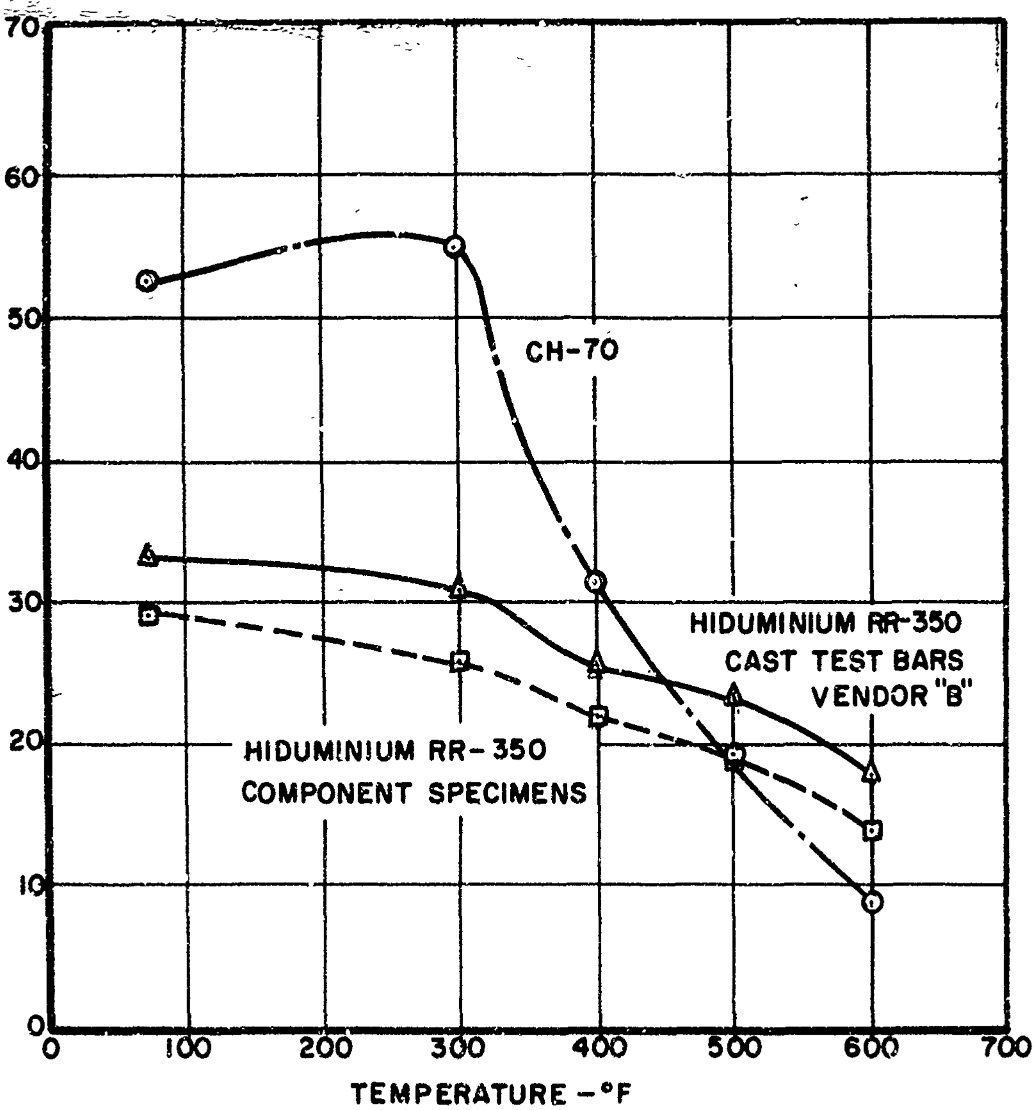

FIGURE 21. HIDUMINIUM RR 350 and CH-70, COMPARISON OF TENSILE YIELD STRENGTH VS. TEMPERATURE FOR 1000-HOUR EXPOSURE

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13. ABSTRACT

A test program was conducted to obtain mechanical properties data on two aluminum casting alloys. Work included tensile, creep, and rupture tests at room temperature, 300, 400, 500, and 600°F. The alloy, Hiduminium RR-350 was developed as a high temperature alloy. Its room temperature properties were moderate but it held its strength quite well up to 600°F. The alloy CH-70 was developed as a high strength, high performance alloy in the 60,000 ultimate tensile strength, 50,000 yield strength, and 5% elongation range. Tensile properties of CH-70 held up well at the 300° test temperature but decreased rapidly at higher temperatures.

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